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Original Article

CATEGORISATION OF SEASONAL VARIATION IN CULTIVABLE LAND UTILIZATION USING LANDSAT IMAGES - A CASE OF NAYAGRAM BLOCK, JHARGRAM DISTRICT, WEST BENGAL, INDIA

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ABSTRACT

Categorisation of cultivable land utilization is a key element for the monitoring and estimation of crop producing area as well as to establish a programme of cropland management. Such categorisation can be done either in temporal span or in spatial difference. In this study attention is focused on assessing the prevailing difference in cultivable land utilization with respect to different seasons. The object oriented general classification of satellite data only leads to common information on the status of cultivable land utilization. However specified classification approach (SCA) can be effectively used to facilitate multi seasonal crop and non-crop area delineation. The newly developed approach of classification has further enhanced by giving new dimension to training set collection. The application of RS and GIS technique leads to estimate the seasonal variation in cultivable land utilization (SVCLU) based on multi spectral satellite imagery of the different seasons i.e. Kharif, Ravi and Zaid for the year 2010 - 2011.

KEYWORDS: Classification, Categorization, Specified Classification, Seasonal Variation, Land Utilization & Crop Area

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1. INTRODUCTION

Production is the function of land, labour, capital and organization. However, in agricultural sector the importance of land is rated top most as the production of crop directly depends on availability of cultivable land. At present the rapid increase of population has resulted additional utilization of agricultural land to fulfil their miscellaneous demands contrasting to the fact that the supply of land is limited and cannot be stretched according to demands. It is proved by the fact that the availability of per capita arable land in India has decreased alarmingly from 0.34 hectares in 1951 to 0.17 hectares in 2001 (Sharma & Ram 2009) [I]. The matter of providing food to all along with the issue of shrinkage in arable land has given birth to a relevant challenge which can never be addressed unless the utilization of land resource is maximized.

The concept of looking to the cultivable land utilization from the perspective of spatial change (Pierce 2007) [II] in net cropped area with changing season is known as seasonal variation in cultivable land utilization (SVCLU). On the basis of advent and retreat of south west and north east monsoon, three agricultural seasons are practiced in Indian subcontinent i.e. Kharif, Ravi and Zaid. There exists mark dissimilarity of seasonal cropped area in most of the agro producing areas. The area of Kharif is still largest as our peasants are more interested to grow crops with the help of nature gifted monsoonal rain water. In spite of infrastructural advancement and several campaigns in irrigation sector a large portion of cultivated land still devoid of irrigation. A proper assessment of

cultivable land on the basis of no. of crops grown in a particular year i.e. single or double or multi is of fundamental importance in the present world (Roy 2012) [III].

The most precise method of determining SVCLU through base level data collection by agricultural field visit is indeed very costly and requires skilled manpower. Beside collection of such a large amount of data within a stipulated time period i.e. span of a particular season is considered to be a mammoth task. However in the present work emphasized are given on integrated studies using remotely sensed satellite image and GIS tools. Satellite data in conjunction with sufficient ground truth is considered as a reliable source of information for any geospatial analysis. This kind of study not only save time and money but also increase the accuracy of the result as the biasness from the part of data collector is minimized.

2. STUDY AREA

Nayagram, a community development block having an area of 501.44Km^2, located in south western part of West Midnapur district of West Bengal state, bounded by 22 º 44 / N to 22 º 74 / N latitude and 88 º 08 / E to 88 º 13 / E longitude has been selected for on-going research rationale. The Study area possesses an undulating topography having a gentle to moderate slope from north-west to south east direction. Elevation of the area varies between a maximum of 110 m. in central north to a minimum of 10 m. in south east. The drainage of the area is controlled by Subarnarekha river system. The Subarnarekha basin forming a part of metamorphic terrain of Chota Nagpur Plateau has attracted the attention of eminent earth scientists for past years. But the area under consideration has received mere attention in this regard.

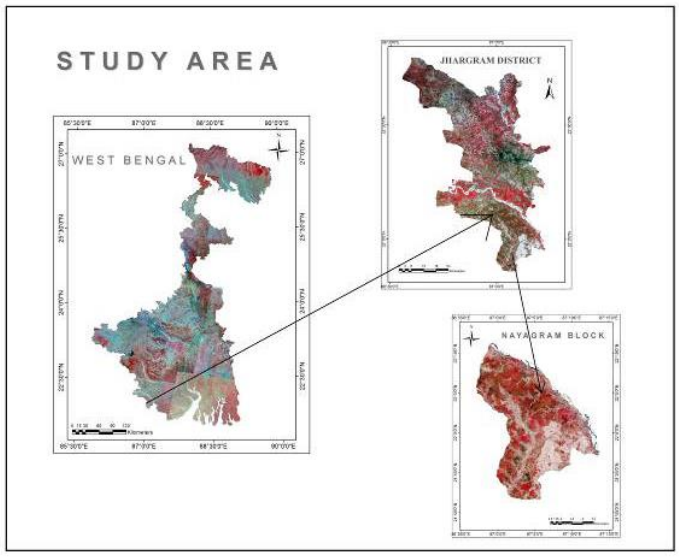

Figure 1: Location of the Area

The area falls under tropical monsoon climate with hot and humid summer. Average annual rainfall for the basin is around 1615 mm. Mean minimum temperature of coolest and mean maximum temperature of warmest months is 13 º C and 35 º C respectively. The study area can be divided into 4 soil categories namely, coarse loamy typic ustifluvents, coarse loamy typic haplsfalfs, fine loamy ultic paleustalfs, fine loamy aeric ochraqualfs. The plateau is covered with a variety of different habitats of which Sal forest is predominant. Beside forest a large parts is covered with bamboo grasslands and shrubs. The selected study area has a total population of 142199 among which 40 % are tribal population (Census of India, 2011).

3. METHODOLOGY

3.1. Software and Data Used

For the derivation of band combination statistics and image classification TNT Mips 2012 and for mapping and presentation Arc GIS 10.1 has been used. Landsat satellite images for the month of November, February and April covering the selected area were used. Images are collected for the agricultural season 2010 to 2011. The specifications of the products are described in table 1.

Table 1: Satellite Data Used

Season	Kharif	Ravi	Zaid
Digital image	Landsat 7 ETM	Landsat 5 TM	Landsat 5 TM
Path / Row	139 / 44 &139 / 45		
WOID	L5007727 & L5007980	L5010473 & L5010471	L6206755 & L5996999
Date of acquired	07.11.2011	13.02.2010	02.04.2010
Resolution	30 m.	30 m.	30 m.

3.2. Specified Classification Model

All the calculations and experiments are done for the images of Kharif, Rabi and Zaid season to show the distribution of cultivable land and its seasonal variation. The methodology of the present appraisal was primarily based on an integrated approach backed by data analysis based on Geographical Information system.

3.2.1 Classification Approach

Literatures inspected prior to this study have revealed that researcher commonly used indices approach to discriminate cropped area from satellite images (Bannari 1995, Choudhury 1987) [IV, V]. This discrimination was done on the mechanism of significant difference in both absorption and reflectance of electromagnetic radiation in Red and Near Infra-Red (NIR) region due to the high amount of chlorophyll content in crop land. NDVI, SAVI, TSAVI are some renowned vegetation index which are frequently used in this regard for their high sensitiveness to vegetation and insensitiveness to soil-background (Ghulam et al. 2007) [VI].This approach is indeed very much challenging and bound to suffer from lack of accuracy (Nash 2009) [VII] while applying it in an area mix with dense vegetation and agricultural tract as found in the case of present study.

In order to mitigate such challenges, a unique non parametric approach of multispectral image classification, specified classification approach (SCA) was developed in this regard. This has been introduced not only to minimize the mixing of crop class with vegetation class but also to achieve a universal acceptance as a powerful cropped area discriminating approach. Rees (2001) [VIII] described image classification as the process of making quantitative decisions from image data, grouping pixels of the image into classes intended to represent different physical objects or types. It is the most popularly used information extraction technique in digital remote sensing (Bhatta 2013, Moyra 2014) [IX, X]. In SCT pixel sorting is done in order to cluster the pure crop pixel and reduce errors from target class.

3.2.2 Training Sites for Classification

The geometric relations in the spectral feature space of bands are also regarded as a good indicator for the selection of training sites. During the selection of training sites for second order classification correlation of Red and near-IR bands are used to identify cropped area (Figure 2). Soil reflectance in Red and near-IR represents high correlation

with a positive correlation coefficient and are distributed along a line, called soil line (Liang 2004) [XI]. This soil line is characterized by a linear equation (1). The scatterplot in the Red and near-IR spectral space often constitutes a triangle shape. Those pixels with higher near-IR reflectance locate above the soil line are identified as a full grown crop.

$$pn = (b + \gamma.pr) \quad (1)$$

(Where, b and γ are the intercept and slope of the soil line. Baret et al. (1993) [XII] derived a standard coefficients value of b = 0.037 and γ = 1.176 for the delineation of soil line.)

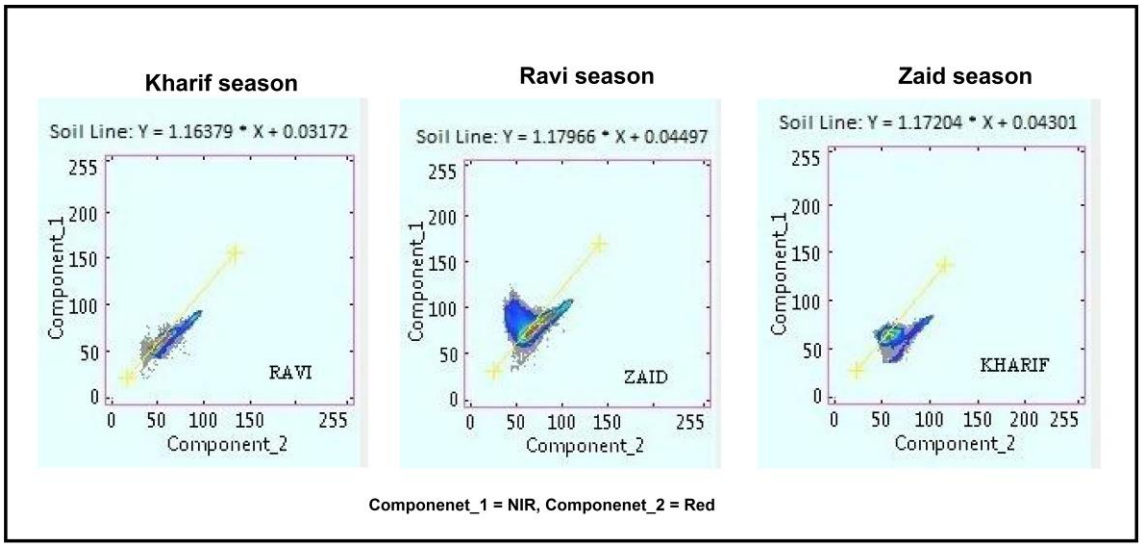

Figure 2: Correlation of Red and Near-IR Bands in Different Seasons

3.2.3 Adoption of Decision Rule for Successive Classification

The decision rule is mathematical algorithm that allows the pixels to group into distinct class values on the basis of data contained in the training set signature (Rahaman 2001, Sahu 2008) [XIII, XIV]. In this process spectral appearances of individual pixel in the image are compared with the estimated cover type signatures. If it satisfies the predetermined criteria fixed for a cover type, respective pixel is assigned to the cover type that matches to set criteria. There are several types of decision rule exist in the arena of GIS field.

In this decision rule, both variance and covariance of the training class pixels are computed. As the classifier delineates ellipsoidal contours with the equal probability in the scatter diagram (Lillesand and Kifer 1994) [XV], their variance about the central value is represented by mean vector and covariance method. On the basis of these two parameters probability of a candidate pixel belonging to each signature class is computed and compared with other alternative classes. Ultimately pixel is assigned to the class which it actually belongs or it is left as unidentified. The algorithm for the classifier is as follows:

$$D = \log(ac) - [\,0.5 \log(Covc)\,] - [\,0.5\,(X-Mc)\,T\,(Covc^{-1})\,(X-Mc)\,] \quad (2)$$

(Where, D = likelihood distance; c = a particular class; X = the measurement of the candidate pixel; Mc = the mean vector of the sample of class; ac = probability of pixel to be a member of class; $Covc$ = the covariance matrix of the pixels in the sample of class; T = transposition function.)

3.3 Linear Combination

Here seasonal cropland layers have been converted to binary raster and each of them was assign with the coded value 1 and 2. Numerical value 1 and 2 were used to represent cropland and fallow land respectively for each seasons. Thus one can easily identify the seasonal variation in cultivable land utilization (SVCLU). At last all three raster layers were combined in a linear fashion following the equation 3 to categorize the study area in terms of seasonal variation in cultivable land utilization (Thompson 1980) [XVI].

$$\mathbf{SVCLU} = \sum \mathbf{Cr} * \mathbf{n} \qquad \mathbf{(3)}$$

(Where, ***Cr*** = each season; ***n***= no. of seasonal raster)

4. RESULT AND DISCUSSIONS

The Landsat 5 TM satellite image for the month of February was classified to monitor the cultivable and non-cultivable segment. The total cultivable area was assumed as 297.365 Km.^{2}. In the present study, determination of cultivable area is done by the process of reclassifying of land use groups based on general land use identification. The cultivable area has been used for three seasons by means of polygon extraction.

4.1 Specified LULC

Unlike the general LULC, the spectral variability in the Red and near-IR region can be considered as the determining factor for specified LULC which is basically prepared with the goal to determine how effectively crop pixels are grouped. Based on this fact specified LULC of cultivated area is prepared for three different seasons having 6 classes each (figure 3). What is most important to note that among the 6 classes only one class have identified as crop class based on spectral triangle concept and rest 5 classes were consists of non-cultivable spectra.

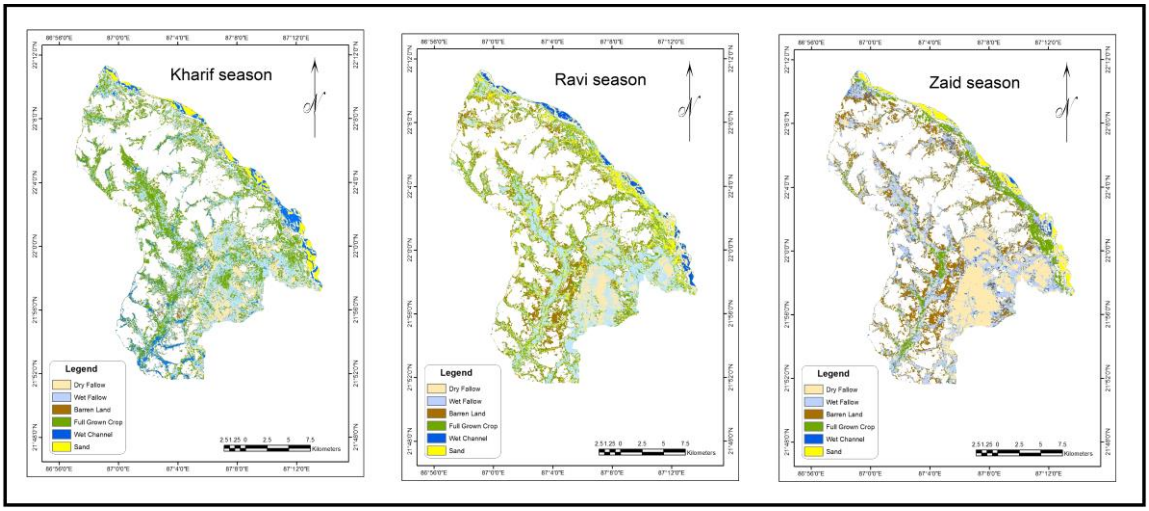

Figure 3: Specified LULC Raster of Three Seasons

In case of specified LULC generation, there must present some loss of information. Hence accuracy assessment is always required while generalizing with RS data (Asraf1992, Panigrahy 1998) [XVII, XVIII]. With the help of Kappa coefficient the classified is quantitatively determined with the help of table 2. Accuracy of full grown crop is found 99% and above for Ravi and Zaid season resembling very high level of accuracy. Accuracy of Kharif is found 91.43%, slightly below but above the overall Kharif accuracy of 91.20 %.

Table 2: Accuracy of Specified LULC

Specified LULC Class	Kharif		Ravi		Zaid	
	Producers Accuracy	Users Accuracy	Producers Accuracy	Users Accuracy	Producers Accuracy	Users Accuracy
Dry Fallow	97.33%	99.37%	95.27 %	98.94%	98.91%	100.00%
Wet Fallow	91.71%	74.68%	92.40%	88.89%	82.47%	63.24%
Barren Land	100.00%	52.54%	100.00%	87.21%	96.45%	96.20%
Full Grown Crop	91.43%	96.48%	99.00%	85.34%	99.68%	100.00%
Wet Channel	63.76%	96.94%	100.00%	100.00%	81.75%	82.35%
Sand	100.00%	100.00%	86.59%	100.00%	100.00%	91.98%
Overall Accuracy	91.20%		95.09%		97.79%	
Kappa Statistics	0.8812		0.9269		0.9306	

4.2 Seasonal Variation in Cultivable Land Utilization

In order to distinguish cropped area from fallow area five specified LULC groups i.e. Dry fallow, Wet fallow, Barren land, Wet channel and Sand classes are merged for three different seasons. Thus raster layers having spatial information of cropped and fallow characteristics are prepared.

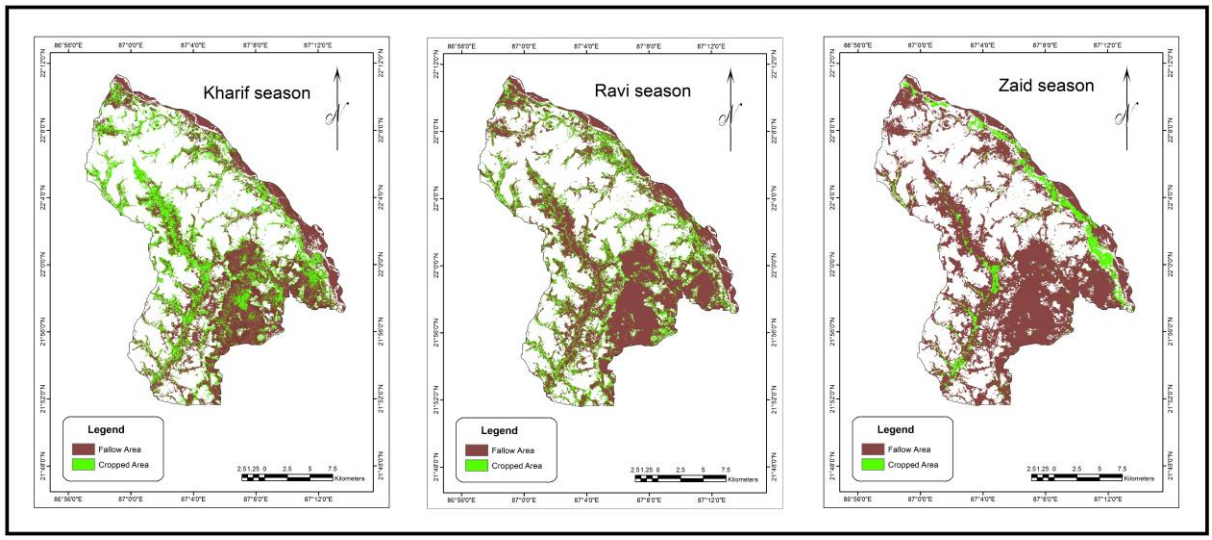

Figure 4: Seasonal Cropped and Fallow Area

Studying the figure 4 and go through with the generated statistics of seasonal variation as shown in table 5, it was shown that there exist a mark seasonal variation in spatial extension of cropland. It increases in the Kharrif season with favorable agro climatic condition and reaches its base in Zaid season with prevailing adversity due to dryness of soil and lack of irrigation facility. In figure 9 efficiency of land utilization in terms of different seasons is represented by percentage value.

Table 5: Seasonal Variation

Cropping Season	Cropped Area (Km^2)	Seasonal Mean Area (Km^2)	Deviation from Mean (Km^2)	Standard Deviation
Kharif	107.385	72.400	+34.98	30.090
Ravi	75.912		+3.512	
Zaid	33.913		-38.487	

4.3 Categorization of SVCLU

Identified both classes, i.e., crop and non-crop area of each raster for Kharif, Ravi and Zaid season was assigned with the code 1 and 2 respectively. Code 1 is represented by crop area and code 2 signifies fallow area. Finally the linear combination of the three binary raster of the respective seasons following the equation 3 has produced the categorization map of SVCLU (figure 5). From which different code type of values has depicted typical crop lands like values having single 1 and double 2 are either Kharif or Ravi or Zaid crop lands which are of single crop land type; double 1 and single 2 are either Kharif and Rabi crop lands or Kharif and Zaid or Ravi and Zaid which are double crop land type and 111 is Kharif, Ravi and Zaid crop land which are triple or multiple crop land.

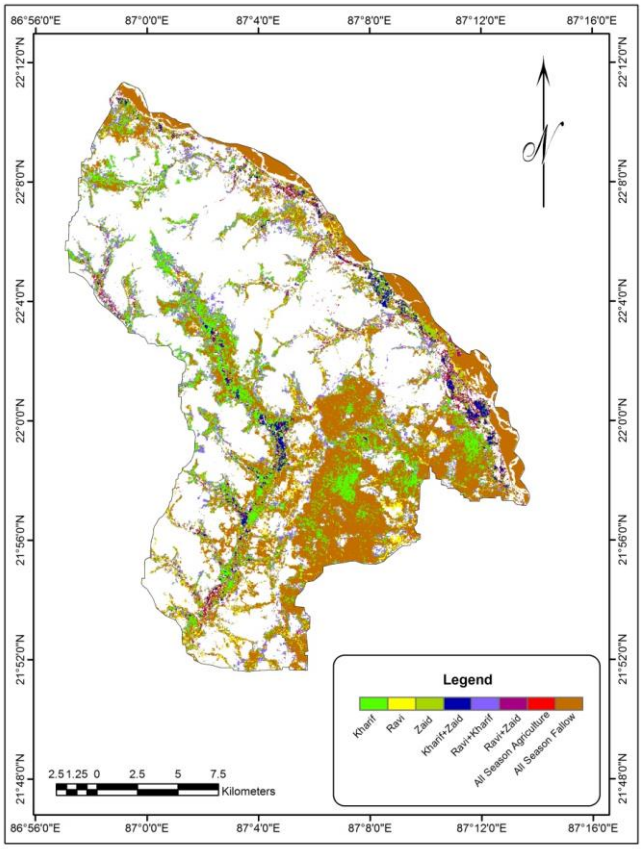

Figure 5: Categorization of SVCLU

5. CONCLUSIONS

Variation in cropped area is regarded as an important parameter to measure the availability of food. Due to unfavorable condition some time the cropped area reduced heavily. On the basis of field data collection it is quite impossible to calculate the exact figure of shrinkage or increase. Present specified classification model will enable to classify the full grown crop area from Landsat image. During the modelling precaution has been taken to collect all three season image with full grown crop.

Overall analysis of our study explore that multi seasonal analysis enables to find out the seasonal variation in cultivable land utilization as well its categorization. Total of 8 agriculture land use class has been derived which helped to trace the land utilization dynamics of the area. It is evident from the findings that the area is mono cropped area with

maximum weightage on Kharif class. Specified classification approach provides effective options to truly group the agricultural feature. With the present approach a new methodology of monitoring the SVCLU e.g. single crop to double, double to triple and vis. have been developed.

6. FINANCIAL AND ETHICAL DISCLOSURES

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Conflict of interest: The authors declare that they have no conflict of interest.

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